Graphene and Plasmonics: the Nanoscale Challenges for Real-time Spectroscopic Ellipsometry

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The improvement of technologies towards a more sustainable development and use of energy resources and devices has received an increasing interest worldwide in recent decades. There is consensus that this improvement needs corroborating materials synthesis and device fabrication processes with in-situ real-time characterization. Elucidating the synthesis-processing-material-functionality interplay is also a key issue in fundamental science, necessary to advance basic knowledge of materials and to manipulate their properties at the nanoscale (*i.e., moving towards the 2020 vision of "Materials on demand")*.
Spectroscopic Ellipsometry has a long tradition in the science and technology of thin films and surfaces also in situ and in real time, from which we can benefit for the analysis of materials at the nanoscale.
Therefore, this contribution overviews how spectroscopic ellipsometry, which is a non-destructive, nonintrusive, noninvasive, and contactless optical technique, has evolved into an efficient characterization tool for a large variety of systems ranging from stacked ultrathin layers to semiconductor nanocrystals and metal nanoparticles, and recently to graphene-based hybrids.
It will include:
-an overview of the fundamentals, limitations, and strategies for the measurements and analysis of nanometric films, metal nanoparticles and semiconductor nanocrystals and periodic structures.
-examples of the applicability of ellipsometry in plasmonics, to understanding the growth of various metal nanoparticles, also in core-shell configuration, as well as of novel nano-alloys, to tailor their localized surface plasmon resonance.
-examples of the exploitation of ellipsometry to optimize and understand CVD growth (using CH_4-H_2) of graphene on nickel (Ni) and copper (Cu) and establishing correlations between process kinetics and graphene thickness. It will be shown how the synergy with real-time ellipsometry monitoring allows to understand and improve critical steps in graphene CVD fabrication, including substrate preparation, carbon diffusion kinetics and the impact of the H_2/CH_4 ratio on CVD growth kinetics, thickness and structural and optical properties of graphene.
Finally, interface chemical and optical phenomena in hybrid nanomaterials created by combinations of graphene, metal nanoparticles, and self assembled monolayers of organic/bio molecules will also be presented, creating a connection to their applications in molecular electronics, photonic, electronic, optical, imaging, catalysis, sensing devices, photovoltaics, and energy savings and storage.

[1] M. Losurdo "*Applications of ellipsometry in nanoscale science: Needs, status, achievements and future challenges"* Thin Solid Films 519 (2011) 2575.
[2] M Losurdo, *Spectroscopic Ellipsometry and polarimetry for materials and systems analysis at the nanometer scale: state-of-the-art, potential and perspectives"* J. Nanopart. Res. 11, 1521 (2009).